UDC 65.01

A Model for Data Mining System in Financial Crisis Management Based on Data Warehouse Concept

Ljiljana Kašćelan,
Faculty of Economics, Podgorica, SCG
Dragana Bečejski-Vujaklija,
Faculty of Organizational Sciences, Beograd, SCG

Abstract: This paper deals with identification and analyses of business decision processes in financial crisis management and appropriate relational data warehouse design for this processes. Also, here a model for financial crises symptoms is proposed and a data mining algorithm for automatic detection of those symptoms is developped. Finally, paper presents the concept for realization of target data mining system, using Oracle tools.

1. Introduction

Crisis, which is present for a long period of time in region of former Yugoslavia, implies that huge number of firms, have loses and bad financial condition i.e. illiquidity. Privatization process, which is on scene, will significantly change attitude toward such firms. New owners of these firms will try to protect their own interests. In such circumstances, there is no doubt that issue of recovering and restructuring of these firms will be very actual. Issue of financial crisis management is very complex and comprises multidisciplinary set of actions and business decisions. Good decision, made in right moment, is key of success of whole rehabilitation operations of firm. In this paper theoretical frame of computerized data mining system in financial crisis management, based on relational data warehouse concept is defined. This includes following:

- identification of basic decision making models in financial crisis management,
- proposal of data warehouse concept, which supports those decision making models, and its realization,
- proposal of a detection model for financial crises symptoms,
- definition of data mining algorithm for automatic detection of financial crisis symptoms, based on above mentioned model and

- at the end, representation of an overall architecture for target data mining system, based on Oracle platform, and testing of the system performance on case study data.

2. An Overview of Financial Crisis Management

Firm crisis is a process, which endangers critical goals of a firm (profitability and liquidity). According to [1], crisis represents a crucial point in a series of unsuccessful business incidents and moves, after which two situations can occur: liquidation of the firm (bankruptcy) or successful overcoming of the crisis (rehabilitation). Typical crisis process begins with almost imperceptible obstruction of the goals and values of the firm. Intensity of the obstructions successively increases until it endangers the very existence of the firm.

Crisis represents an exceptional situation for the firm, which poses substantially more complex demands in kind and scope to the management, in comparison to normal situations. Crisis management must be characterized by speed and determination. Management must have the ability to choose right measures and determination to carry them out in a limited amount of time.

Symptoms of a crisis, at an early stage which does not represent a danger to the existence yet, are downfall of incomes, downfall of profitability, increase in debts, downfall of cash flow and downfall of liquidity [1]. Symptoms of an existence-endangering crisis which causes the need for firm rehabilitation, are balance sheet loss or defictive balance, where the loss shown is greater than one third or one half of basic capital, and liquidity curtailment [8] [9]. According to [2] [4] [6] [11], rehabilitation implies a set of financial, technical and organizational measures which are taken in order to recover the firm, to make it liquid and profitable anew. Symptoms of a crisis that liquidates a firm (bankruptcy) are balance sheet overdebt where balance loss surpasses the amount of own capital and nonliquidity [8] [9].

According to [10], crisis symptoms can be clearly detected from the basic financial statements only in the second phase of the crisis, while early detection of the crisis is possible if in addition to such statements other sources of information are used, particularly those arising from the comparison of the magnitudes planed and realized per certain functional areas.

Basis for establishing the need for rehabilitation, establishing the causes of crisis and choice of rehabilitation measures is Opening Rehabilitation Balance Sheet, which is formed according to last year's annual statement. Based on this sheet different rehabilitation measures are simulated, i.e. rehabilitation is projected. As a result of measures taken, Closing Rehabilitation Balance Sheet is made, which represents the basis for overseeing the effects of rehabilitation measures. Also, the expression "Rehabilitation Balance Sheet" is most commonly applied to this balance sheet [7].

In business practice of developed economies turnarounds are more common than rehabilitations. It is a change of business course, but in an earlier phase of a crisis, before the firm falls into a liquidity crisis.

Particularly important issue is what information and in which form are necessary for managing a financial crisis. According to [3], managers who specialize in reviving failing businesses rated the importance and availability of seven types of reports (financial, working capital, cost, expense, personnel, asset and market analyses). They consider financial and working capital analyses most important. For all seven types of analyses, turnaround managers prefer current information that is either by cost/profit centers or detailed, and for all but asset reports, a monthly reporting interval is preferred.

3. Identification and Analyses of Business Decision Processes in Financial Crisis Management

Management in financial crisis enviroment is very complex set of business decisions and undertaken actions, which, according to [5], can be decomposed in following decision processes:

1. Detection of financial crisis symptoms,
2. Estimation of opportunity of undertaking rehabilitation measures,
3. Choice of rehabilitation measures and their bookkeeping,
4. Tracking of effects of rehabilitation measures,
5. Rehabilitation termination.

In Figure 1. further decomposition of these processes is shown. Atomic processes, i.e. processes which represent leaves of decomposition are decision making processes on which design of target data mining system is based on[1].

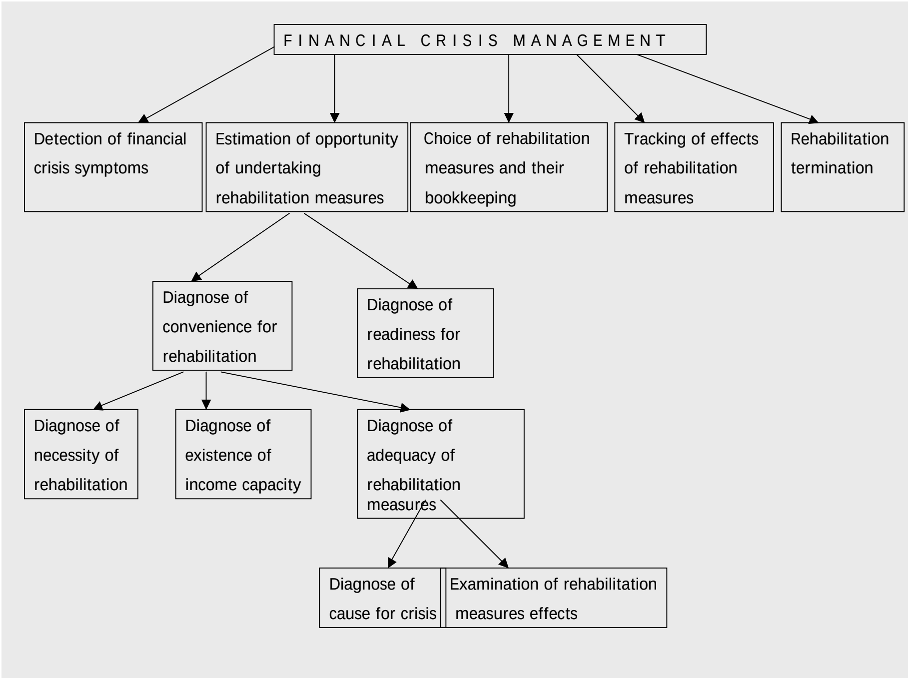


Figure 1. Decomposition of decision making processes in financial crisis management.

During analyses of decision making processes in financial crisis management, in [5] are identified decision models for these processes (Table 1.).

Decision Making Processes	Models
Detection of financial crisis symptoms	Multidimensional model for market and sales analyses, Model for costs analyses, Cash-Flow model, Function of deficitive balance (FDB), Function of liquidity curtailment (FLC)
Automatic detection of financial crisis symptoms	Function of deficitive balance (FDB), Function of liquidity curtailment (FLC)
Diagnose of necessity of rehabilitation	Balances at the beginning of rehabilitation process (multidimensional model for balance analyses)

[1] Barring processes *Choice of rehabilitation measures and their bookkeeping* and *Rehabilitation termination,* which belongs in range of standard IS.

Diagnose of existence of income capacity	Balances at the beginning of rehabilitation process, Multidimensional model for market and sales analyses, Model for costs analyses, Break-even model
Diagnose of cause for crisis	Function of deficitive balance (FDB), Function of liquidity curtailment (FLC), Models for alternative decision making (profitability of products, customers, sales channels), Multidimensional model for market and sales analyses, Model for costs analyses, Break-even model, Balances at the beginning of rehabilitation process (What-if analyses)
Examination of rehabilitation measures effects	Models for projections of rehabilitation process (What-if analyses)
Tracking of effects of rehabilitation measures	Balances during of rehabilitation process (multidimensional model for balance analyses)

Table 1. Models for support business decision processes in financial crisis management

Model for Automatic detection of financial crisis symptoms, based on Function of deficitive balance (FDB) and Function of liquidity curtailment (FLC) is applied in this data mining system.

4. Data Warehouse Design and Realization

In this paragraph a data warehouse design and a method of its realization is defined which supports those decision making processes. Table 2. shows facts, measures and dimensions on which identified decision making models are based on.

Models	Facts	Measures	Dimensions
Model for market and sales analyses	Sales	Units, Revenues, Costs, Profit	Calendar, Customers, Products, Sales channels, Sales places
Model for costs analyses	Costs	Debit, Credit, Balance	Calendar, Analytical accounts for costs
Cash-Flow model	Balances	Debit, Credit, Balance	Calendar, Accounts in balance sheet
Function of deficitive balance (FDB)	Balances	Debit, Credit, Balance	Calendar, Accounts in balance sheet
Function of liquidity curtailment (FLC)	Balances	Debit, Credit, Balance	Calendar, Accounts in balance sheet
Balances at the beginning of rehabilitation process	Balances	Debit, Credit, Balance	Calendar, Accounts in balance sheet
Models for alternative decision making	Sales	Units, Revenues, Costs, Profit	Calendar, Products
Break-even model	Costs	Debit, Credit, Balance	Calendar, Analytical accounts for costs

Balances at the beginning of rehabilitation process (What-if analyses)	Balances	Balance	Calendar, Accounts in balance sheet
Models for projections of rehabilitation process (What-if analyses)	Balances	Balance	Calendar, Accounts in balance sheet
Balances during of rehabilitation process	Balances	Balance	Calendar, Accounts in balance sheet

Table 2. Data warehouse design

From this table we can see that data warehouse concept consists of three data marts :

- **Data Mart** *Sales* which contains fact *sales* and measures *units, revenues, costs and profit* with dimensions *calendar, customers, products, sales channels* and *sales places*. Data from transaction subsystem for sales are data source for this data mart.
- **Data Mart** *Balances* which contains facts *balances* (per period and cumulative at the end of the period) and measures *debit, credit* and *balance* with dimensions *accounts in balance sheet* and *calendar*. Data from transaction subsystem for financial accounting are data source for this data mart.
- **Data Mart** *Costs* which contains fact *costs* and measures d*ebit, credit* and *balance* with dimensions c*alendar* and *analytical accounts for costs.* Data from transaction subsystem for costs analytical accounting are data source for this data mart.

Data warehouse concept, based on these facts, is realized using *Oracle Warehouse Builder* [13]. By this tool we can create data warehouse objects and procedures for data mapping from different sources into these objects. Possible data sources are: relational databases (Oracle, SQL Server, IBM DB2,...), flat files, *Oracle Designer* repository and SAP application. Mapping comprises extraction, transformation and loading data into target warehouse schemas. Possible transforms are: Oracle library, custom (PL/SQL) transforms and SQL operations such as filter and aggregation functions. As a result, *Builder* generates the following kinds of scripts from a configured set of definitions: DDL scripts that create objects for the physical instance, PL/SQL and SQL*Loader routines that extract, transform, and load data and TCL scripts that run jobs that load and refresh the physical instance. Further on is given description for data marts realization by this tool.

<u>Warehouse Module Sales</u>. On Figure 2. *sales* star schema and objects of dimension *products* are shown. The following mapping sequence is defined for warehouse module *Sales* : 1. mapping of dimensions *products,*

customers, channels, sales places and *time*; 2. mapping from source to staging table (summarization of transactions per day); 3. mapping from staging table to fact table (calculation of profit); 4. mappings for materialized views which represent their SQL definition. Figure 3. shows materialized view (aggregation) cs*_pd_saleSUM*, generated by omission of dimensions *sales channels* and *sales places*, and its mapping[2].

Warehouse Module Balances. For that warehouse module, the following mapping sequence is defined: 1.mapping of dimensions *accounts in balance sheet* and *time*; 2. mapping from source to staging table 3.mapping for summarization of transactions per day; 4. mapping from staging table to fact table (calculation of balance per day); 5. mapping from staging table to fact tables (calculation of cumulative balance till certain day, week, month, quarter and year); 6.mappings from fact tables to materialized views. Figure 4. shows mappings from steps 2 and 3.

Warehouse Module Costs. In this module the mapping sequence is defined as follows: 1. mapping of dimensions *analytical accounts for costs* and *time*; 2. mapping from source to staging table 3.mapping for summarization of transactions per day; 4. mapping from staging table to fact table (calculation of balance per day); 5.mappings from fact tables to materialized views.

[2] Materialized views, which aggregate data on higher dimensional hierarchy level, are defined using *Discoverer*. For query rewrite server equally use materialized views, created by this tool, and by *Builder*.

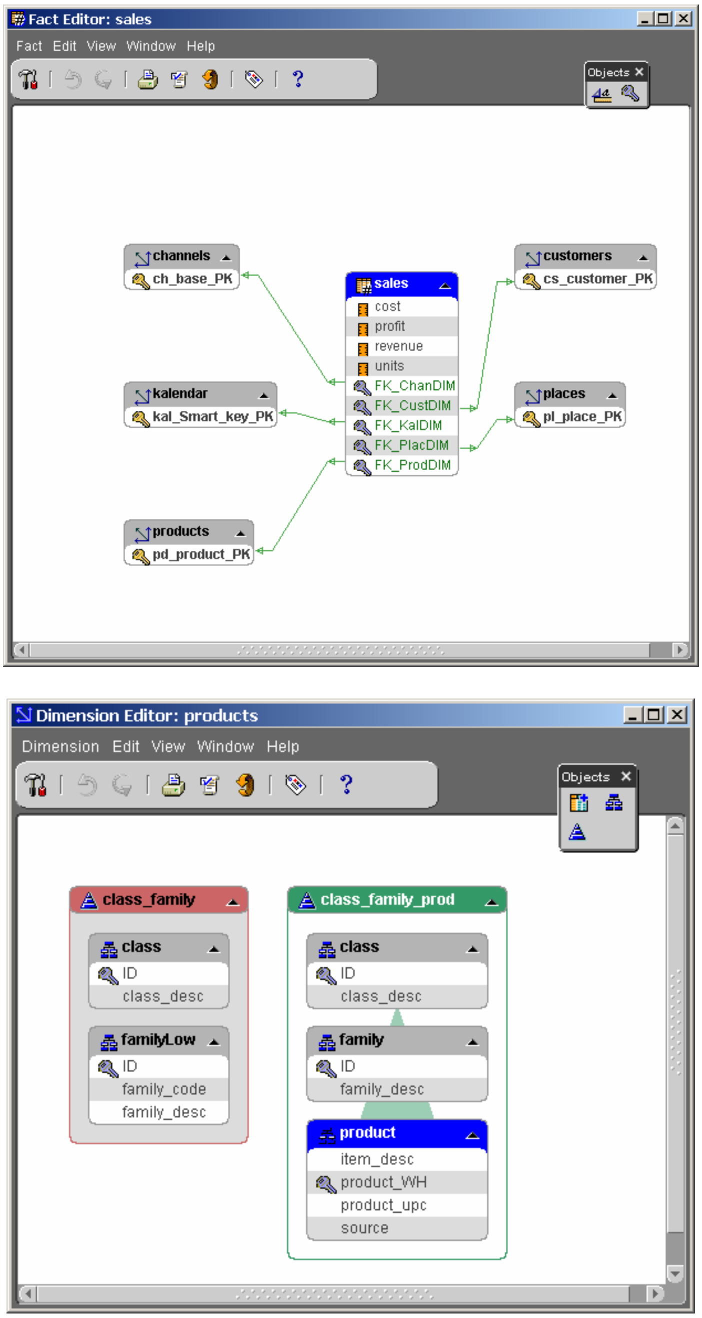


Figure 2. Star schema *sales* and dimension *product*

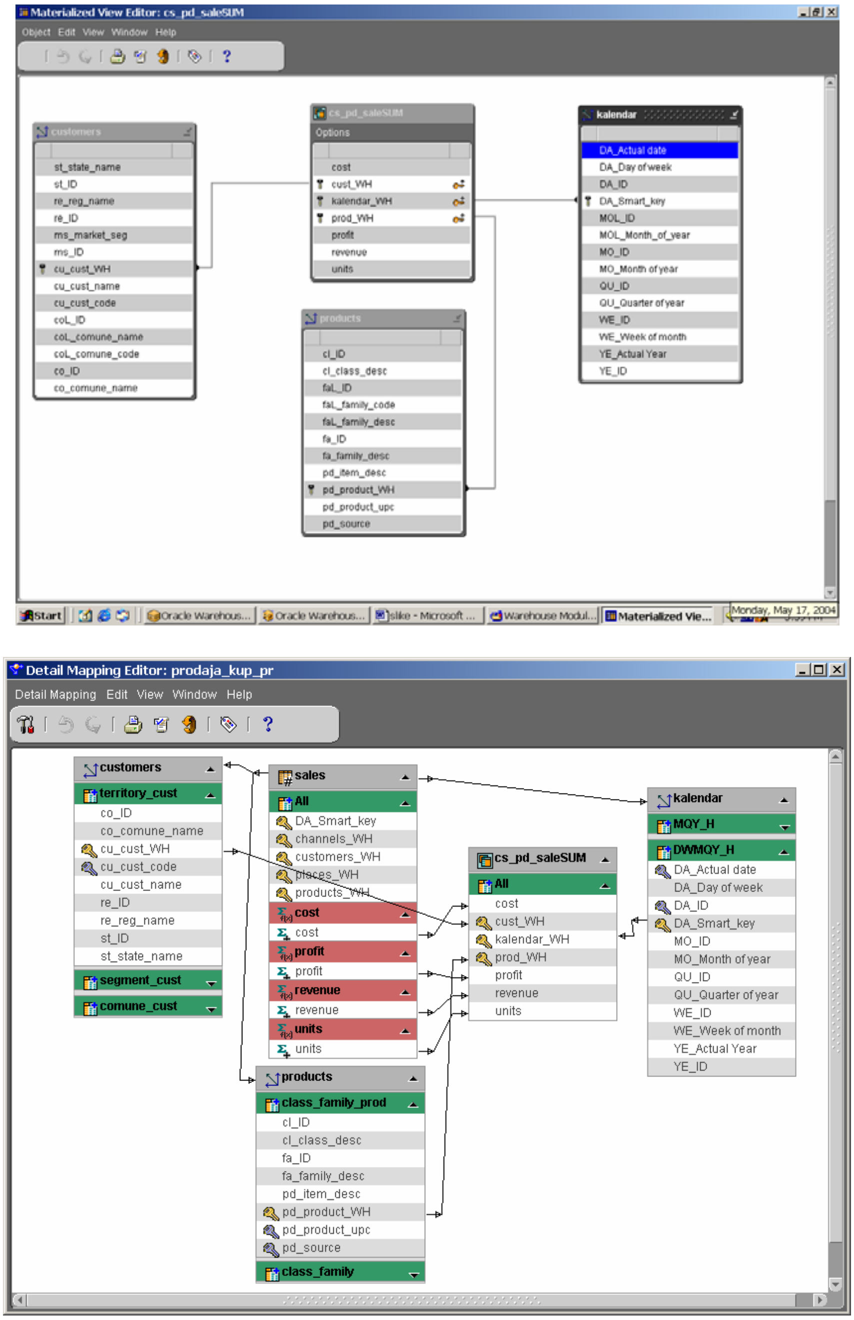


Figure 3.: Warehouse module *Sales*: A materialized view - schema and mapping

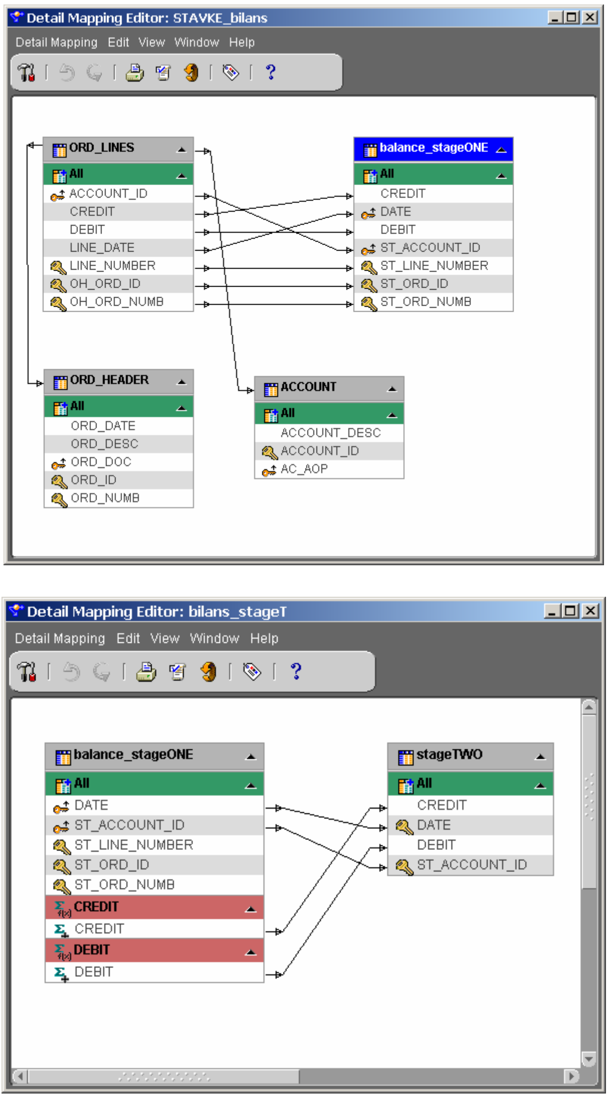


Figure 4. Warehouse module *Balances*: Mappings from steps 2 and 3

5. A Model for Financial Crisis Symptoms Detection

The main problems in construction of financial crises detection models are the choice of variables, which describe crises. This problem was solved in this model using two time series variables *Deficitive Balance* and *Liquidity Curtailment.*

a) Variable : *Deficitive Balance*

Def: *Deficitive Balance Function* is function FDB : I→ R, where I={ t_1, t_2, t_3,...} is a set moments of time, defined as follows:

Let OK (t_i) be a value of position of charter capital at the moment t_i, R(t_i) be a value of position of reserves at the moment t_i, ND(t_i) be a value of position of undistributed last year profit at the moment t_i, G(t_i) be a value of position of losses at the moment t_i, and SK(t_i) be a value of position of treasury capital at the moment t_i; according to [9] it follows that

$$SK(t_i) = OK(t_i) + R(t_i) + ND(t_i). \quad (1)$$

Balance treasury capital at the moment t_i is

$$BSK(t_i) = SK(t_i) - G(t_i) \quad (2)$$

It follows that

$$FDB(t_i) = OK(t_i) - BSK(t_i) . \quad (3)$$

Now, symptom of financial crisis i.e. occuring of deficitive balance can be written in the form

$$\exists\, t_i \in I \text{ such as } FDB(t_i) > 0 \quad (4)$$

It means that a part of charter capital is wasted .

However, for forecasting this symptom we need to define event D_1 which indicates probably occuring of deficitive balance. Event D1 is defined with expression (5).

$$\exists\, t_i, t_{i+k} \in I \text{ such that } (\forall\, t \in [t_i, t_{i+k}]\ (FDB(t) \le 0 \wedge FDB(t) \uparrow)) \wedge |FDB(t_{i+k}) - FDB(t_i)| > ATG) \quad (5)$$

i.e., FDB is nonpositive and increasing function on interval [t_i, t_{i+k}] , where t_i is a moment of time in which the FDB starts to increase, and t_{i+k} is a moment of time in which $|FDB(t_{i+k}) - FDB(t_i)|$ becames greater than an in advance defined allowable threshold of growth.

b) Variable: *Liquidity Curtailment.*

Def: *Liquidity Curtailment Function* is function FLC : I→ R, where I={ t_1, t_2, t_3,...} is a set moments of time, according to [9], defined as follows:

Let $CA(t_i)$ be the part of current assets which consists of cash or items that can be quickly (at the moment ti) converted into cash, I (t_i) be a value of inventories at the moment t_i and $CL(t_i)$ be a value of current liability at the moment t_i; it follows that

$$FLC(t_i) = (CA(t_i) + I(t_i)) - CL(t_i) . \quad (6)$$

Now, symptom of financial crisis, i.e. occuring of illiquidity, can be written in the form

$$\exists\, t_i \in I \text{ such that } FLC(t_i)<0 \quad (7)$$

However, for forecasting this symptom we need to define event D_2 which indicates probably occuring of illiquidity. Event D2 is defined with expression (8).

$$\exists\, t_i, t_{i+k} \in I \text{ such that } (\forall\, t \in [t_i, t_{i+k}] (FLC(t) \geq 0 \wedge FLC(t) \downarrow)) \wedge \left| FLC(t_i) - FLC(t_{i+k}) \right| > ATD \quad (8)$$

i.e., FLC is nonnegative and decreasing function on interval $[t_i, t_{i+k}]$, where t_i is a moment of time in which the FLC starts to decrease, and t_{i+k} is a moment of time in which $\left|FLC(t_{i+k}) - FLC(t_i)\right|$ became greater than an in advance defined allowable threshold of decline.

6. A Data Mining Algorithm for Automatic Detection of Financial Crisis Symptoms

Algorithm is based on above detection model and on data which were prepared as appropriate data warehouse structures.

Figure 5. shows an example of data preparation for the data mining algorithm. The data warehouse structures are created by mapping from cumulative (till day, week, month, quarter and year) fact tables into this data mining tables, on this way:

- calculation of FDB and FLC values (figure left , PL/SQL transformations : *calc_fdb, calc_flc)*, based on its definitions by (2) and (6) from previous section,
- calculation of indicator for increase of function FDB (figure right, PL/SQL transformation *ind_increase*), which has value 1 if current value of function is greather then value from previous moment, otherwise 0 and

- calculation of indicator for decrease of function FLC (figure right, PL/SQL transformation *ind_decrease*) has value 1 if current value of function is less then value from previous moment, otherwise 0;

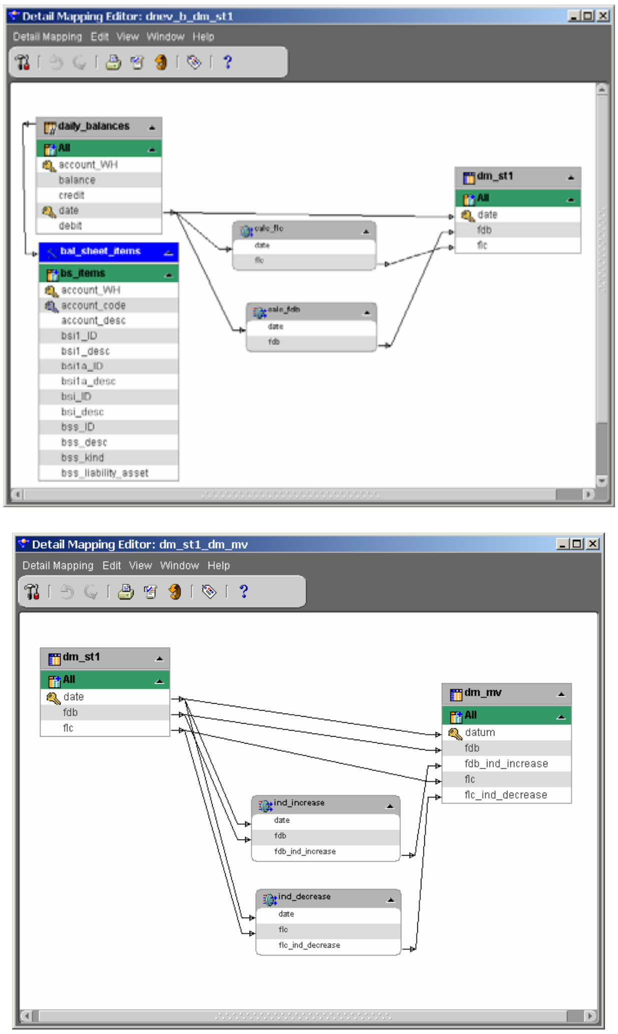


Figure 5. Data preparation for data mining algorithm

Figure 5. shows mappings from cumulative fact tables on daily level. Data mining tables on weekly, monthly, quarterly and yearly level are prepared similarly.

Basic idea of this algorithm is: first, we fetch data from appropriate data minig table into certain arrays, depend on the time dimension level, which was determinated from user. Now, for any succession of numbers one in the indicator arrays, we check whether a value of increase of FDB or decrease of FLC, became greater than an advance defined allowable threshold. This checking starts from last items of indicator arrays. If we detect such succession of numbers one, the further search will be stoped. Thus, detected succession, in fact, presents data from last crisis period. Now, we can all basic ideas sumarize in the folowing algorithm:

```
Algorithm 1: Financial crisis symptoms detection
Input :
 LEVEL data aggregation level (daily, weekly, monthly, quarterly, yearly)
 ATG most allowed threshold of growth FDB and
 ATD most allowed threshold of decline FLC.
Output : Warning about symptoms
Method:
{
Arrays_Making ( LEVEL, FDB[ ], FLC[ ], FDB_IND[ ], FLC_IND[ ], N);
D1 = Def_Bil ( ATG, FDB[ ], FDB_IND[ ], N );
D2 = Liqu_Curt ( ATD, FLC[ ], FLC_IND[ ], N );
IF ( D1 OR D2) Run_Alarm( );
}
Procedure: Arrays_Making
Input: LEVEL
Output: FDB[ ], FLC[ ], FDB_IND[ ], FLC_IND[ ], N
Method:
{
N=0;
SWITCH (LEVEL) {
CASE 'day' :...
CASE 'week':...
CASE 'month' :
 FOREACH
 dm_mv_m. fdb-> FDB[ N ]
 dm_mv_m. fdb_ind_groth -> FDB_IND[ N ]
 dm_mv_m. flc-> FLC[ N ]
 dm_mv_m. flc_ind_decl -> FLC_IND[ N ]
 N=N+1;
 END FOREACH;
 BREAK;
CASE 'quarter':...
CASE 'year':...
DEFAULT:... }
}
Function : Def_Bil
Input: ATG, FDB[ ], FDB_IND[ ], N
Output : D1
Method :
{
WHILE (N>0) {
 WHILE ( N>=0 AND FDB_IND[ N ]==0 ) N=N-1;
 END=N;
 WHILE ( N>=0 AND FDB_IND[ N ]==1 ) N=N-1;
 START=N;
 IF ( abs ( FDB[END] - FDB[START]) > ATG ) {
 D1= TRUE ;
```

```
 RETURN D1;
 }
 }
D1= FALSE;
RETURN D1;
 }
Function : Liqu_Curt
Input: ATD, FLC[ ], FLC_IND[ ], N
Output : D2
Method :
{
WHILE (N>0) {
 WHILE ( N>=0 AND FLC_IND[ N ]==0 ) N=N-1;
 END=N;
 WHILE ( N>=0 AND FLC_IND[ N ]==1 ) N=N-1;
 START=N;
 IF ( abs ( FLC[END] - FLC[START] ) > ATD ) {
 D2= TRUE;
 RETURN D2;
 }
 }
D2= FALSE;
RETURN D2;
}
```

7. Conceptual Design for Data Mining System realization

System for support above identified decision processes and models, is an *Data Mining System* based on relational data warehouse and relational OLAP. However, process of crisis symptoms detection is based on analyses of actual data. Consequently, a component of system which support that process falls into category of executive information systems (EIS). Process of automatic detection of crisis symptoms is realized as a data mining algorithm, which periodically observes data. If symptoms are occured, data mining process automatic generates warning.

Concept of system realization, which is shown in Figure 6., is based on *Oracle* data warehousing (*Oracle Warehouse Builder*) [12][13], and *Oracle Discoverer* (OD) [14][15].

Oracle Discoverer is an *ad-hoc query* tool which is based on relational data warehouse. This tool is comprised of two components- the administrator and user tools. *Oracle Discoverer Administrator (ODA)* prepares the data structures that the user will use to access the data warehouse (business areas).This end user layer (EUL) insulates end users from database complexity. *Oracle Discoverer Plus* is user component which allowes defining, creation and formation of workbooks from certain business area. Thus, if we use this tool for realization, by *Discoverer Plus* we can customize and analyse models. Also, we can define and generate these models, using ODA.

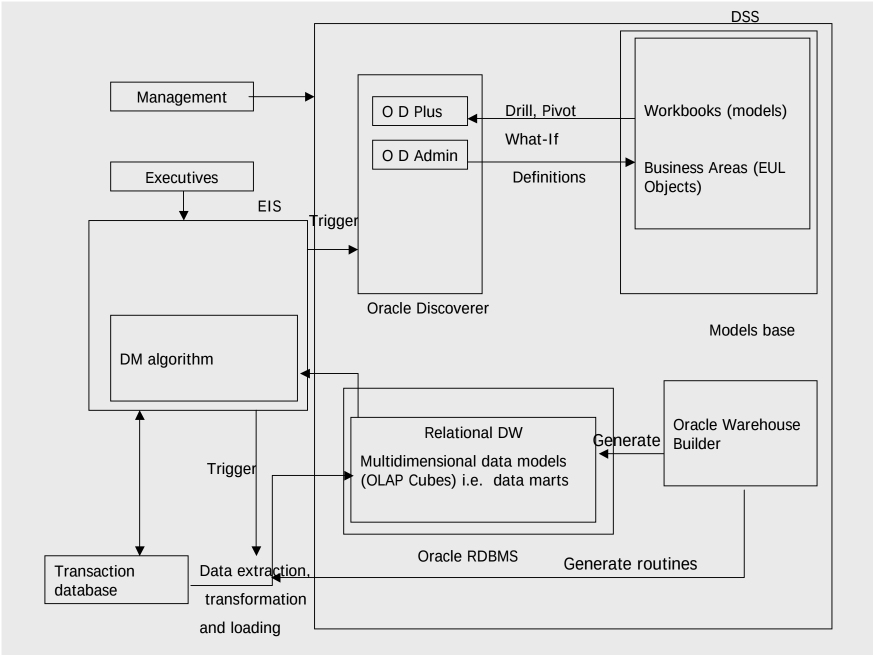


Figure 6. Conceptual design for data mining system realization

Discoverer has direct access to the relational database. It is very simple to generate and analyze huge number of different models by it. It has no limits to use available functions and analytical capabilities.

8. Case study

Applying this concept to the data from the database of a regional company, in [5] it is shown that system gives desirable results. Data are from period between years 1996 and 1999. Case study hardware was : *COMPAQ*, *x86 Family 6 Model 8 Stepping 6 GenuineIntel*, 930MHZ, 522672 KB RAM and 18.6 GB HD. Case study software was: *Microsoft Windows 2000 Professional, version 5.0.2195, Oracle Warehouse Builder 2.1.1* and *Oracle Discoverer 4.1.*

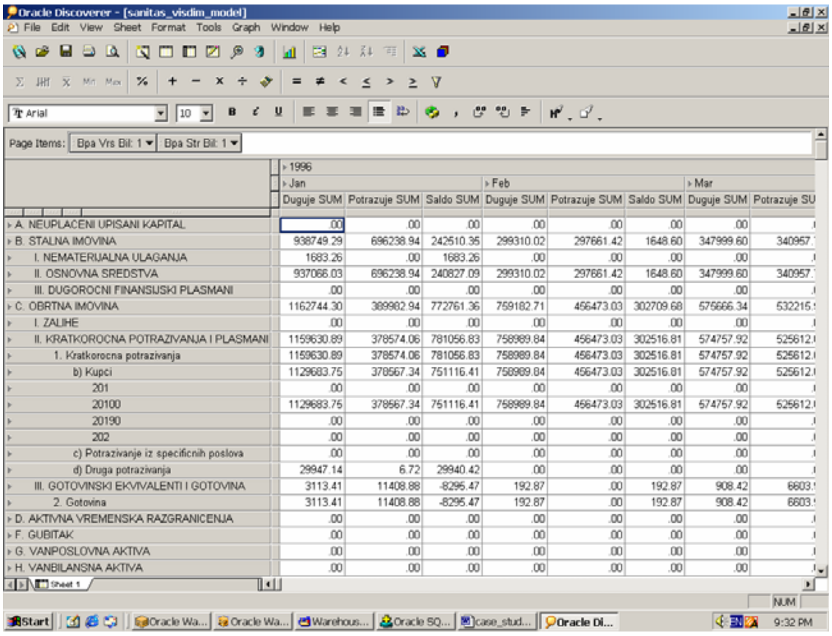
Initial loading time, i.e. execution time for mapping procedures, was very good. Execution time for mapping procedures based on basic COPY transformation was about 40 seconds (for about 40000 data records).

Execution time for mappings which presents calculation of cumulative balance and data minig relevant data was somewhat longer (duration of calculation of cumulative balance was 4 minutes; calculation of functions FDB and FLC lasted about 8 minutes). Procedures were more faster because we have generated appropriate indexes.

Then, *Oracle Discoverer* is used to generate identified decision making models. Models based on fact table *balances* (with 35774 data records), are generated for less then 15 seconds. *Drill-down* and *pivot* operations (for same number of data records), are executed immediatlly, but *collaps* (*drill-up*) operation lasted somewhat longer (about 10 seconds). Query performance is really improved because we have generated appropriate materialized views. In Figure 7. (above) we can see a multidimensional model for balance analyses of case study firm, on monthly level. This model presents a left side of the balance sheet (assets). In Figure 7. (below) pattern of change for monthly FLC and FDB between 1996 and 1997 year for case study firm are shown.

From model which presents pattern of change for monthly FLC and FDB, we can conclude the following:

- During 1996 year firm had been working without losses (function FDB is negative) and with satisfactory liquidity (function FLC is positive).
- Starting from eighth month of 1996 year, function FDB increases. This indicates a deficitive balance (occuring of losses which are greater than amount of reserves and undistributed last year profit)
- Starting from seventh month of 1996 year, function FLC decreases. This points to liquidity curtailment.
- For second month of 1997 year value of function FDB is equal zero. This means that deficitive balance is occured in this moment.
- At the end of seventh month of 1997 year, value of function FLC is equal zero, because firm for a long period of time had been working with losses. It means that firm became illiquidly in this moment.
- From second month of 1997 year, firm works with deficitive balance or on margin of deficitive balance (function FDB is positive or near to zero).
- From seventh month of 1997 year firm works with illiqudity or on margin of illiqudity (function FLC is negative or near to zero).



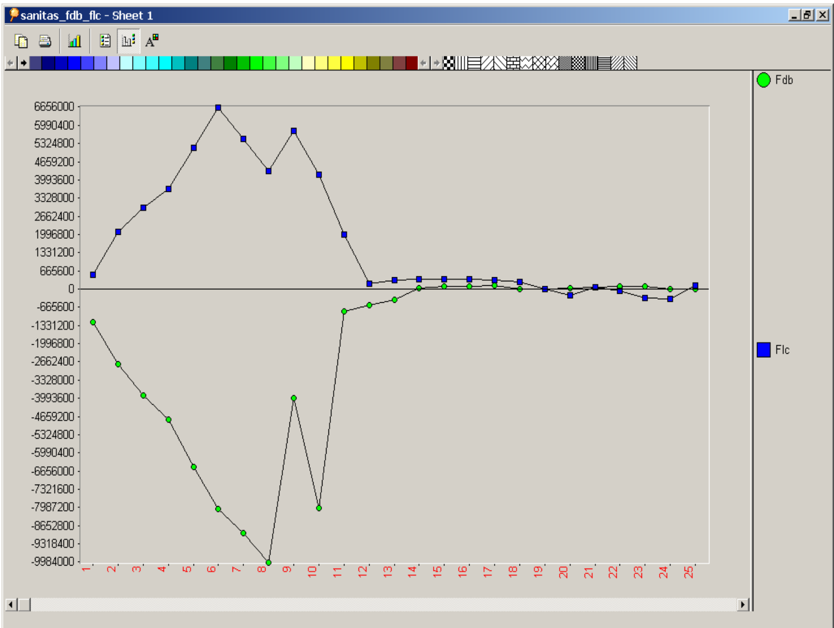


Figure 7. Some *Discoverer* models for case study firm

9. Conclusion

In this paper theoretical frame of computerized data mining system in financial crisis management is defined, based on *Oracle* data warehouse concept. By this system we can automatically detect financial crisis symptoms and also generate and analyse huge number of different models for decision making support in this field of activity.

References

1. Bokenforde Bjorn: Unternehmenssanierung, Schaffer-Poeschel Verlag, Stuttgart, 1996
2. Brombach, Olfert, Ehreiser: Sonderbilanzen, Kiehl Verlag, Ludwigshafen (Rhein), 1976
3. Fredenberger, Lipp, Watson: Information Requirements of Turnaround Managers at the Begining of Engagements, Journal of MIS, Vol13, No4,1997
4. Heinen Edmund: Handelsbilanzen, 11. verbesserte Auflage, Gabler Verlag, Wiesbaden,1985
5. Kašćelan Lj.: A Model for Decision Support System in Financial Crisis Management Based on Data Warehouse Concept, PhD, Faculty of Economics, Podgorica, 2002
6. Knoll Heinrich, Beyer Erwin: Bilanzkunde, 5. Auflage, Gabler Verlag, Wiesbaden,1978
7. Peemöller Volker, März Thomas: Sonderbilanzen, Physica-Verlag, Heidelberg Wien 1986
8. Ranković J.: Theory of Balances, Faculty of Economics, Belgrade, 1992.
9. Ranković J.: Special Kind of Balances, Faculty of Economics, Belgrade, 1996
10. Škarić-Jovanović K.: Usefulness of the Financial Statements for Rehabilitation Management, XXXII Conference of SRJ Accountants, Belgrade, 2001
11. Weinrich Dr Günter, Hockmann Heinz J.: Sonderbilanzen, Gabler Verlag, Wiesbaden,1982
12. Oracle 8i Data Warehousing Guide, Release 2 (8.1.6), 2001
13. Oracle Warehouse Builder, Users Guide, Release 2.1.1, Oct 2000
14. Oracle Discoverer Plus, Users Guide, Release 4.1, Dec 2000
15. Oracle Discoverer Administration Edition, Users Guide, Release 4.1, Dec 2000

Ljiljana Kašćelan graduatet at the Faculty of Science (Department of Mathematics) of the University of Montenegro, in 1992. She received her M.Sc. degree from the Faculty of Electrical Engineering (Department of Computers) in 1996, at the same University. She completed her Ph.D. at the Faculty of Economics, in 2002, at the University of Montenegro. Currently, she works as an Associate Professor at the Faculty of Economics at the University of Montenegro, where she lectures in several Informatics courses. Hers research interests are in the area of Decision

Support Systems, Data Warehouse and Data Mining Systems. She is the author of over 20 papers in the area.

Dragana Becejski-Vujaklija is an associate professor of IT management at the Department of Information Systems and Technology, Faculty of Organizational Sciences, University Belgrade, Serbia & Montenegro. Her current research areas are IS management and implementation (Procedure making, System performance setup and harmonizing, User training), as well as research in information systems preliminary design (Information request defining, Data source identifying, Dimensional modeling). Her current projects are in the field of Executive information systems development. She is also the editor of two vocational journals.